

1 **AUDIO CONTROLLER FOR PORTABLE ELECTRONIC DEVICES**

2 **BACKGROUND OF THE INVENTION**

3 **1. Field of the Invention**

4 The present invention relates generally to portable devices for reproducing audio
5 recordings, and more particularly, to a device for reproducing compressed digital audio
6 recordings. Particular utility for the present application is in the reproduction of MP3
7 digital audio files, especially for use with portable computers, however other utilities are
8 contemplated herein.

9 **2. Description of Related Art**

10 Presently there exist various portable devices for replaying digital audio
11 recordings that have been compressed in accordance with a compressed audio digital
12 recording format called MP3. These devices can be divided into two classes, those which
13 store the MP3 compressed digital audio recordings in an electronic solid state memory,
14 and those which record the compressed digital audio for subsequent reproduction using
15 an electro-mechanical device such as a compact disk ("CD") player or on a hard disk
16 drive of a digital computer.

17 Portable devices for replaying MP3 compressed digital audio recordings that use
18 electronic solid state memory, i.e. flash-memory, are capable of storing about ten (10)
19 music selections. With an add-in memory card, such devices can carry a total of about
20 twenty (20) music selections. These MP3 players that store the MP3 compressed digital
21 audio recordings in an electronic solid state memory consume comparatively little
22 electrical power. Thus, such MP3 players provide an extended playing interval without

1 battery replacement or recharging for the limited number of selections which they can
2 store.

3 In addition to having a capacity for only a limited number of music selections,
4 another characteristic of portable MP3 players that store compressed digital audio
5 recordings in an electronic solid state memory is the inconvenience associated with
6 loading the music selections into that memory. In general, such MP3 players require first
7 downloading or obtaining copies of MP3 compressed digital audio recordings on a hard
8 disk drive of a personal computer, and then transferring the MP3 compressed digital
9 audio recordings from the personal computer to the portable MP3 player. The preceding
10 operations are to be contrasted with the simplicity of merely inserting a compact disk
11 ("CD") into a CD player, or playing MP3 compressed digital audio recordings directly
12 from a hard disk drive or CD drive of a digital computer.

13 MP3 players which preserve compressed digital audio recordings for reproduction
14 using an electro-mechanical device are capable of storing many more music selections
15 than portable MP3 players that store compressed digital audio recordings in an electronic
16 solid state memory, e.g. hundreds or even more than one-thousand. However, usually
17 MP3 players that use electro-mechanical devices require significant amounts of electrical
18 power. Thus, portable players that reproduce music selections using an electro-
19 mechanical device exhibit comparatively short playing interval, e.g. less than one (1.0)
20 hour before batteries must be replaced or recharged.

21 Batteries used in laptop and notebook computers usually permit their operation
22 for several hours before becoming discharged. As is readily apparent, a laptop or
23 notebook computer can be to play MP3 compressed digital audio recordings using either

1 the computer's CD-ROM or hard disk drive. Pending United States Patent Application
2 Serial No. 09/136,207, now U.S. Patent No. _____, entitled "Low Power CD-
3 ROM Player for Portable Computers" that was filed on August 19,1998, which is hereby
4 incorporated by reference in its entirety, describes how a conventional laptop or notebook
5 computer, when simply playing a conventional music CD, consumes an unnecessarily
6 large amount of electrical energy. Such an excessive electrical energy consumption
7 drains a laptop or notebook computer's battery of power that is more prudently applied in
8 performing microprocessor intensive tasks such as word processing and spreadsheet
9 analysis. The solution presented in the '207 application is a state machine that operates
10 when main power to the portable device is OFF. The '207 invention couples a CD-ROM
11 to the audio subsystem (when main power is OFF) so that CDs can be played, without
12 excessive battery drain, or without having to boot up the portable computer.

13 SUMMARY OF THE INVENTION

14 Accordingly, it is one object of the present invention to adapt laptop and notebook
15 digital computers for reproducing compressed digital audio recordings when main power
16 to the computer system is OFF. Another object of the present invention is to adapt
17 laptop and notebook digital computers for storing MP3 compressed digital audio
18 recordings into a conventional portable MP3 player using as little energy as is
19 practicable.

20 In one embodiment, the present invention provides a computer system adapted to
21 play audio files which includes a computer subsystem comprising a system CPU and a
22 drive for storing audio data. The computer system also includes an audio controller
23 comprising a drive interface for selectively accessing the audio data from the drive and

1 memory for storing the audio data. Advantageously, The controller is adapted to access,
2 store and play the audio data when power is not being supplied to said computer
3 subsystem.

4 In another embodiment, the present invention provides a computer system
5 adapted to play audio data when said computer system is inactive, the computer system
6 including a computer subsystem comprising a system CPU and a drive for storing audio
7 data. An audio controller is provided comprising a drive interface for selectively
8 accessing the audio data from the drive and decoder circuitry for decoding the audio data
9 and generating a decoded signal. The controller is adapted to access the drive to retrieve
10 the audio data and decode the audio data when said computer subsystem is inactive.

11 In method form, the present invention provides a method for playing audio files in
12 a computer system when said computer system is in an inactive state includes the steps of
13 activating an audio controller if a main CPU of a computer system is inactive; selecting
14 desired audio data; and generating an audio data stream from said selected audio data.

15 It will be appreciated by those skilled in the art that although the following
16 Detailed Description will proceed with reference being made to preferred embodiments
17 and methods of use, the present invention is not intended to be limited to these preferred
18 embodiments and methods of use. Rather, the present invention is of broad scope and is
19 intended to be limited as only set forth in the accompanying claims.

20 Other features and advantages of the present invention will become apparent as
21 the following Detailed Description proceeds, and upon reference to the Drawings,
22 wherein like numerals depict like parts, and wherein:

1 Brief Description of the Drawings

2 Figure 1 is an exemplary block diagram of a portable system in an ON state
3 adapted to receive and play MP3 digital audio files, according to one embodiment of the
4 present invention;

5 Figure 2 is an exemplary block diagram of a portable system in an OFF or
6 inactive state adapted to receive and play MP3 digital audio files, according to one
7 embodiment of the present invention;

8 Figure 3 is a more detailed system block diagram of the invention of Figures 1
9 and 2;

10 Figure 4 is a detailed block diagram of the MP3 audio controller of the invention
11 of Figures 1 and 2;

12 Figure 5A is an exemplary block diagram of another embodiment of the present
13 invention, depicting a portable system in an ON state, adapted to receive and play MP3
14 digital audio files, and utilizing an external MP3 decoding device; and

15 Figure 5B is an exemplary block diagram of another embodiment of the present
16 invention, depicting a portable system in an OFF or inactive state adapted to receive and
17 play MP3 digital audio files, and utilizing an external MP3 decoding device.

18 Detailed Description of Exemplary Embodiments

19 Figures 1-4 depict an example of the preferred MP3 audio controller of the
20 present invention. As an overview, the present invention is directed to an MP3 audio
21 controller 18 adapted to play stored MP3 files. It is intended, in this embodiment, that
22 the MP3 controller of the present invention be integrated within a computer system 10
23 (e.g., portable lap-top computer) and is adapted with the necessary logic to permit

1 selection, retrieval and play of MP3 files stored locally on the computer, without the
2 necessity of having the computer system turned ON. As used herein, the term inactive is
3 defined to mean a state in which main power is not being supplied (i.e., an OFF state), or
4 when the system is in a sleep mode (such as may be defined under power management
5 specifications). Thus, the present invention provides significant power savings when
6 playing MP3 audio files.

7 Figure 1 depicts a computer system 10 adapted with the MP3 controller 18 of the
8 present invention in an ON state. Generally, the computer system 10 includes a system
9 CPU 12, a Corelogic chipset 14, a hard disk drive (HDD) 20, a CD-ROM drive (CD) 22,
10 and an audio subsystem (denoted as “audio IC”) 16 coupled to a speaker system 24.
11 When main power is being delivered to the system 10 (i.e., the computer is ON), it is
12 preferable that the MP3 controller does not control the play of MP3 files, since such
13 functionality is usually handled by the CPU 12 and an MP3 decoder (typically software).
14 Thus, when the system is ON, the MP3 controller 18 is transparent to commands between
15 the drives 20 and/or 22 and the CPU. Although the figures depict drives 20 and 22 as a
16 hard disk device and a CD-ROM device, respectively, it is intended that any drive
17 mechanism (e.g., RAM drive, DVD drive, backup drive, etc.) known to those skilled in
18 the art can be substituted for these drives 20 and/or 22 without departing from the present
19 invention.

20 Conversely, when the system is OFF, as depicted in Figure 2, the MP3 controller
21 of the present invention operates to permit users to traverse the drives 20 and/or 22 to
22 play MP3 files stored therein directly, without requiring that the CPU 12, CPU chipset

1 14, or audio subsystem 16 be operating. To that end, as shown in this Figure, system
2 power need only be supplied to the controller 18, and to the drives 20, 22.

3 The system block diagram of Figure 3 represent a more detailed view of the
4 computer system 10, adapted with the MP3 controller of the present invention. As
5 shown, the CPU 12 and Corelogic chipset 14 (depicted as conventional “North Bridge”
6 and “South Bridge” I/O chipsets) communicate with controller 18, using both an SMBus
7 and an IDE bus. As is understood in the art, coupling of the controller 18 to an SMBus
8 permits the user-programmability of the controller 18. The controller 18 also
9 communicates with the drives 20 and/or 22 along the system IDE bus. As will be
10 described in more detail below, controller 18 can include an integrated audio DAC IC, or
11 be adapted to feed a decompressed MP3 file to an external audio DAC 26. The external
12 audio DAC 26 may be included as part of the integrated computer system 10 and/or a
13 subset of the audio IC 16. In either event, the converted audio files are amplified (at
14 amplifier 28) to provide an audible signal to speaker system 24. Additionally, as noted
15 above, controller 18 is adapted to control drives 20, 22 to read MP3 files therefrom. To
16 that end, to permit users to traverse directory structures on the drives, an external LCD
17 display 30 is preferably provided. The LCD display receives directory information from
18 drives 20 and 22 (via controller 18) and displays that information by file name/location.
19 Likewise, the LCD display preferably displays current status information of the controller
20 18, as will be described in greater detail below. It should be noted that the use of LCD
21 display 30 requires that controller 18 be adapted with appropriate LCD display driver
22 circuitry. It may be the case, however, that the computer system 10 includes and LCD

1 display 34 and LCD driver circuitry 32, in which case, controller 18 may be coupled
2 directly thereto.

3 Figure 4 depicts a detailed block diagram of the MP3 controller 18 of the present
4 invention. As an overview, controller 18 includes an internal processor 48, memory 50
5 and 52, IDE bus interface 54, SMBus interface 42 and MP3 decoding circuitry 56. The
6 overall functionality of controller 18 is the ability to traverse drives 20, 22, permit users
7 to choose a desired MP3 file, decompress the MP3 file and output either a digital or
8 analog signal (to be played by an external amplifier and speaker system). Each of these
9 components depicted in Figure 4 are described below.

10 Processor 48 is provided to control the general I/O functions, including access,
11 traversal and retrieval commands for drives 20 or 22. In the preferred embodiment,
12 external function keys 66 are provided to permit users to operate controller 18 and drives
13 20 or 22 to play MP3 files. Function keys can include play, pause, fast forward, rewind,
14 next track, previous track, scan, etc. (or any combination thereof). Since, in the preferred
15 embodiment, the controller 18 of the present invention permits traversal of directory
16 structures and retrieval of files, it is also preferable to include MENU and ENTER
17 function keys 66. Controller 18 includes a function key interface 46 to interpret
18 commands generated by function keys 66 and generate commands to the processor 48.
19 Instructions for retrieval and play of MP3 files are stored in flash memory 52. These
20 instructions are preferably user-programmable firmware, permanently resident in
21 memory 52. Upon activation of a function key, processor 48 receives instructions from
22 memory 52. To communicate with drives containing MP3 data, a slave IDE interface 54
23 is provided. Upon user commands generated by the function keys, processor 48 instructs

1 slave IDE interface to control one of the drives to begin traversing the directory structure.
2 The directory structure in which MP3 files are stored may be fixed (for example, a
3 directory may be user-specified and stored in flash memory 52), or the controller can
4 permit users to traverse all directories and files on the drive. Once a user has selected an
5 MP3 file and wishes to play that file (by pressing a play function key, for example),
6 processor 48 instructs the slave IDE interface 54 to retrieve that file from the drive.
7 Preferably, to minimize disk activity once a file selection is obtained, the file is
8 transferred into RAM memory 50. It is most preferable to include dual port SRAM 50, as
9 shown, to store both the audio file and to temporarily store instructions and/or program
10 parameters used by the processor 48. Once the audio file is loaded into memory 50, the
11 data is fed to MP3 decoder circuitry 56.

12 Decoder circuitry 56 comprises a stream audio decoder 58, buffer memory 60 and
13 either an internal audio DAC 62, or a DAC interface 64 for communicating with an
14 external audio DAC 26. Stream audio decoder 58 receives streaming audio data from
15 memory 50 and decodes the data according to a decoder algorithm stored therein.
16 Alternatively, a decoder algorithm may be stored in flash memory 52, loaded into
17 memory 50 upon activation of the controller, and supplied to the decoder 58. Either way,
18 it is preferable to permit users to update/modify the decoding algorithm. Accordingly, it
19 is preferable that memory 52 or decoder 58 stores an updatable version of the decoder
20 algorithm. In the preferred embodiment, decoder 58 is an MP3 audio file decoder. The
21 output data generated by decoder 58 is decompressed digital audio data, and may include
22 standard digital audio formats like PCM format data. The decoder outputs the
23 decompressed data to a first in - first out (FIFO) buffer 60. If controller 18 is adapted

1 with an internal DAC, data from the buffer 60 is fed into the DAC 60, which generates an
2 analog audio signal, which in turn is fed to amplifier 28 and out to the speaker system
3 (not shown). Alternately, if an external DAC is available in the computer system 10 (for
4 example, as part of the audio IC), the decoder can include an appropriate interface 64.
5 Interface 64 receives digital data from memory 60 and communicates with an external
6 DAC. In a similar fashion, the external DAC 26 generates an analog signal which is
7 supplied to the amplifier 28 and speaker system.

8 As discussed briefly above, the controller preferably includes an SMBus interface
9 42 to permit controller 18 to communicate with an SMBus of computer system 10. The
10 SMBus is provided for when the system is ON to pass along function key commands to
11 the system 14 and 12, and is also used to access the flash memory 52 of the controller 18
12 to permit upgrades and/or changes therein. Once commands are sent to the interface 46,
13 said commands are communicated to the processor 48 for processing. It is also
14 preferable that controller 18 include an LCD interface 57, which is coupled to the SMBus
15 (via register block 44) and processor 48. In this way, the LCD interface 57 can generate
16 signals indicative of both the users actions via function key interface 46, and the
17 processor status. Processor status may include overall operation status (e.g., file loading,
18 decompressing, file not found, etc.) and specific operational parameters (e.g., error status,
19 component failure, etc.). Additionally, it is preferable to display the drive data, which
20 may include directory tree structure, file name(s), etc. Additionally, MP3 files typically
21 contain an ID tag that is descriptive of the title, song, etc. It is preferable that LCD
22 interface 57 be adapted to read and display this tag data. Thus, LCD interface 57 is
23 preferably adapted to display such drive data generate by processor 48.

1 Controller 18 includes an internal clocking mechanism 40 to clock the circuitry of
2 the controller, and to communicate with timed devices (drives 20 or 22) over a timed bus
3 (e.g., IDE bus). It will be understood by those skilled in the art that more than one clock
4 frequency is typically required, for example, differing clocks supplied to processor 48,
5 decoder 58 and audio DAC 62. The clock mechanism preferably includes a PLL timer
6 that is clocked by a set crystal, as shown.

7 As described above, the controller 18 of the preferred embodiment operates to
8 play compressed audio files when the system 10 is OFF. To that end, it is preferred that
9 the controller 10 is activated by a user pressing one of the function keys (i.e., system
10 power is supplied to controller 18 by pressing one of the function keys 66). Upon this
11 event, power is coupled to the components of controller 18, and to the drive systems 20
12 and/or 22. By the same token, if the system 10 is ON, the controller of the present
13 invention includes switches 68. Switches 68 operate to decouple the controller 18 from
14 the IDE bus (as shown in Figure 3), thereby becoming transparent to the drives 20, 22
15 and the audio subsystem 16.

16 It should be noted that the controller 18 is preferably operable with both hard disk
17 drives 20 and CD-ROM drives 22, either of which are conventional storage media for
18 MP3 audio files. Accordingly, function keys 66 also preferably include activation keys
19 for the CD-ROM drive, which may include EJECT, FF/SCAN-FF, RW/SCAN-RW,
20 PLAY, PAUSE, STOP, MENU, ENTER etc.

21 Figures 5A and 5B depict another embodiment of the computer system 10' of the
22 present invention. Similar to the embodiment of Figures 1 and 2, the present embodiment
23 includes an MP3 controller 18' incorporated into a computer system 10'. In this

1 embodiment, however, the controller 18' is operable with an external MP3 player 70.
2 Figure 5A depicts the system 10' when power is supplied to the system components:
3 CPU 12', Corelogic chipset 14', Audio IC 16' and drives 20' and/or 22'. When the
4 system is on, MP3 audio files stored on either drive 20' or 22' can be transferred to the
5 external device 70. External MP3 players may include a CD player 72 for reading CDs
6 having MP3 files stored thereon, and/or internal memory 74 for temporary storage of
7 MP3 files. Similar to the previous embodiment, controller 18' preferable is transparent to
8 system 10' when power is ON. In Figure 5B, the system components are OFF or
9 inactive. Controller 18' operates to decompress MP3 files and send the decompressed
10 data to external player 74. Alternatively, controller 18' can operate to transmit the
11 compressed data to the external player 74, where the data is decompressed into an
12 appropriate audio format by the player 74. It is preferable that the external device 70
13 include conventional I/O interface (not shown) for connection to controller 18' (via
14 system 10'). For example, controller 18' and player 70 may include conventional RS232
15 (serial), USB, and/or TCP/IP communications to exchange commands and transfer data
16 therebetween. The decompressed files can be stored in memory 74 of the external player
17 70.

18 Controller 18' includes similar components as the controller 18 of the previous
19 embodiment, except that it may not be necessary to include function keys 66 and function
20 key interface 46, since it is likely that portable player 70 includes such functionality.
21 Similarly, it may not be necessary to include display functionality with controller 18' if
22 portable player 70 is equipped with an appropriate display to view drive directory
23 structures and files.

1 Thus, it is evident that there has been disclosed an audio controller for portable
2 electronic devices that satisfies the aims and objectives stated herein. Those skilled in the
3 art will recognize numerous modifications that may be made to the present invention.
4 For example, although the controller 18 and 18' of the present invention has been
5 described with reference to MP3 audio data, it should be readily apparent that the
6 controller 18 and 18' is independent of the specific format of audio data, and should
7 instead be viewed as a general-purpose audio controller capable of receiving, playing,
8 and/or decompressing any type of audio data, not limited to MP3 format data.

9 Other modifications are possible. For example, the controller 18 of Figures 3 and
10 4 is depicted and described as being coupled (or decoupled) to an IDE bus, those skilled
11 in the art will recognize that the controller can likewise include other bus interface
12 technologies, depending on the bus configuration of system 10. Thus, for example,
13 controller 18 may be modified to control SCSI drives, and include an SCSI interface for
14 exchanging commands and data according to SCSI protocols. Likewise, it may be
15 desirable to adapt controller 18 with conventional network protocols (e.g., TCP/IP, etc.)
16 for communication with remote systems (not shown) in a conventional network.

17 Still further modifications are possible. The controller 18 of the present invention
18 has been described herein as including decoding circuitry 56 to decode audio data when
19 the system 10 is OFF. However, it is contemplated that audio files, such as MP3 files
20 could be decoded and stored in a decoded format on the drives 20 and/or 22, for example
21 when the system 10 is ON. If decoded (decompressed) is accessed by the controller 18,
22 this data is stored into memory 50 and supplied directly to audio DAC 62 or audio DAC
23 interface 64. In other words, no decoding is necessary for such data and controller 18

1 plays the decoded data directly. Those skilled in the art will recognize numerous
2 additional modifications, and all such modifications are deemed within the spirit and
3 scope of the present invention, only as limited by the appended claims.